STUDY GUIDE

PHOSPHORUS REMOVAL

INTRODUCTION AND ADVANCED

SUBCLASS I

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PREFACE

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for the Phosphorus Removal Introduction and Advanced exams.

The objectives in this study guide have been organized into four modules: (A) Principle, Structure, and Function; (B) Maintenance and Operation; (C) Monitor and Troubleshooting; and, (D) Safety and Calculation. The objectives are organized to correspond to the major concepts in each module.

New exam questions have been written to correspond to the concepts included in this study guide.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the Phosphorus Removal Exams, you should:

1. Read all the objectives and write down the answers to the objectives that readily come to mind.

2. Use the resources at the end of the objectives to look-up those answers you are not sure of.

3. Write down the answers found in the resources to those objectives you could not answer from memory.

4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT THE OPERATOR ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator", or by contacting DNR District operator certification coordinator.

INTRODUCTION

INTRODUCTION TO PHOSPHORUS REMOVAL

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF PHOSPHORUS REMOVAL

1. Explain how the discharge of phosphorus may impact receiving waters.

2. List some major sources of phosphorus in influent wastewater.

3. Describe the following phosphorus removal processes:

   A. Chemical Precipitation
   B. Biological Uptake.

CONCEPT: STRUCTURE AND FUNCTION

4. List the basic equipment used in the process of removing phosphorus by chemical precipitation.

5. List the materials and conditions used for piping and storage for the following chemicals:

   A. Pickle Liquor (Ferrous Chloride or Ferrous Sulfate).
   B. Ferric Chloride.
   C. Alum.
   D. Anionic Polymers.

6. Discuss the types of chemical feed pumps used in chemical precipitation of phosphorus.

MODULE B: MAINTENANCE AND OPERATION

CONCEPT: MAINTENANCE

7. Describe any special maintenance requirements for chemical phosphorus removal systems.

8. List the preventive maintenance procedures for chemical feed pumps.

9. List the ways of protecting chemical feed pumps from external corrosion.

10. Discuss ways to control corrosion from Ferric Chloride and Pickle Liquor fumes.

CONCEPT: OPERATION

11. Discuss how much sludge could be expected to be produced using chemical precipitation for phosphorus removal.

12. Describe how an operator or municipality could identify influent phosphorus loading to a treatment plant.

13. Identify the major forms in which phosphorus enters a treatment plant and which form of phosphorus is most easily removed.

14. List the most common chemicals used for phosphorus removal.

15. Explain how to regulate the feed rates of phosphorus removal chemicals.

16. Discuss the importance of keeping records of pickle liquor shipping manifests.

17. List the common recycle streams in a treatment plant that may affect chemical feed rates.

18. Discuss the effect of wastewater pH on phosphorus removal efficiency.

19. Discuss the type of polymers used for phosphorus removal.

20. Describe the chemical used to aid coagulation and precipitation of metal phosphate compounds.

21. Discuss the procedures for storing and feeding the following phosphorus removal chemicals:

A. Ferric Chloride.
B. Pickle Liquor.
C. Alum.

22. Discuss the following addition points for Alum, Pickle Liquor, Ferric Chloride, and Polymer.

A. Addition of chemical prior to primary clarification.
B. Addition of chemical just prior to the aeration basin (trickling filter or RBC).
C. Addition of chemical just prior to the final clarifier.

23. Discuss the characteristics of the following phosphorus removal chemicals:

A. Ferric Chloride.
B. Pickle Liquor.
C. Alum.

24. Describe precautions to take to avoid damage to the feed pump while adjusting the chemical feed rate.

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MODULE C: MONITORING AND TROUBLESHOOTING

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CONCEPT: MONITORING

25. Describe a method of determining the amount of chemical that has been removed for use from a storage tank.

26. Discuss various methods for sampling phosphorus removal chemicals from a semi-tanker during delivery.

27. Describe the Resource Conservation and Recovery Act (RCRA) rules that the operators must comply with if using pickle liquor for phosphorus removal.

28. Identify the sampling locations for determining percent phosphorus removal.

29. Describe the approved laboratory procedure for analyzing total phosphorus. List other test methods that may be used for process control.

30. Discuss the cleaning procedure for samplers and sample bottles used for analyzing total phosphorus.

31. Describe how to preserve samples to be tested for phosphorus at a later date.

32. Identify the ways jar tests can be used in the phosphorus removal process.

CONCEPT: TROUBLESHOOTING

33. Discuss what needs to be checked on a chemical feed pump when switching from one chemical to another.

34. Explain how inflow and infiltration (I&I) affects phosphorus removal.

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MODULE D: SAFETY AND CALCULATION

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CONCEPT: SAFETY

35. Discuss preventive measures and clean-up procedure to follow in the event of a chemical spill of Alum, Pickle Liquor (Ferrous Chloride), or Ferric Chloride.

36. Discuss the hazards and clean-up procedure involved in event of a polymer spill.

37. Discuss the possible safety risks involved in the laboratory analysis for phosphorus.

38. Discuss the potential hazardous reactions which may result if the following chemicals are mixed:

A. Ferric Chloride and Concentrated Hydrogen peroxide.
B. Sulfuric Acid (found in Ferric Sulfate pickle liquor) and Hydrochloric Acid (found in Ferric Chloride pickle liquor).

39. Discuss the proper procedure for entering a chemical storage tank for cleaning.

40. Describe the safety equipment to be used when working with phosphorus removal chemicals.

CONCEPT: CALCULATION

41. Given data, calculate the percent phosphorus removal.

42. Given data, calculate the phosphorus loading to a plant in pounds per day.

43. Given data, calculate the pounds of Metal (Aluminum or Iron) in a gallon of solution.

44. Given data, calculate the time (in days) that a volume of chemical will last.

ADVANCED

ADVANCED PHOSPHORUS REMOVAL

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF PHOSPHORUS REMOVAL

1. Describe the major industrial processed that are sources of phosphorus in influent wastewater.

2. Describe the principle biological uptake phosphorus removal process.

CONCEPT: STRUCTURE AND FUNCTION

3. Discuss the importance of selecting proper materials for piping and storage for the following chemicals:

A. Pickle Liquor (Ferrous Chloride or Ferrous Sulfate).
B. Ferric Chloride.
C. Alum.
D. Anionic Polymers.

4. Discuss the function and the most probable location of each of the following:

A. Anti-siphon valves.
B. Check valves.
C. Backflow Preventers.

MODULE B: MAINTENANCE AND OPERATION

CONCEPT: MAINTENANCE

5. Discuss necessary operational and equipment/storage maintenance adjustments for phosphorus removal systems during seasonal changes.

6. List strategies to reduce corrosion problems associated with ferric chloride and pickle liquor fumes.

7. List the chemical/storage precautions associated with a prolonged shut-down of a chemical feed system.

CONCEPT: OPERATION

8. Discuss how using chemical precipitation for phosphorus removal affects sludge production.

9. Explain the phosphorus discharge requirements for treatment plants in Wisconsin.

10. Describe what happens when metal ions combine with phosphorus in the phosphorus removal process.

11. Discuss how phosphorus removal affects treatment costs.

12. Describe strategies to reduce influent phosphorus loading to treatment plants.

13. Discuss the main equipment and operational factors to consider when anticipating a change of phosphorus removal chemicals.

14. Define the following chemical characteristics for each of the common chemicals used for phosphorus removal (ferric chloride, ferrous sulfate, ferrous chloride, and alum).

A. Corrosivity level.
B. Fumes.
C. Temperature of crystallization.
D. Percent metal.
E. Acidity.

15. Describe the potential impact of phosphorus removal chemicals on effluent pH and alkalinity.

16. Discuss the effect of wastewater pH levels on phosphorus removal chemical feed requirements.

17. List reasons for adding phosphorus removal chemicals after primary treatment.

18. List reasons for adding phosphorus removal chemicals to primary clarifier influent.

19. State the advantages of polymer addition.

20. Explain the importance of proper mixing and location of feed points in polymer addition.

21. State why dry alum or polymer must be mixed with water before feeding into the treatment system.

22. Identify where the chemical addition points are located in typical activated sludge and trickling filter/RBC plants for the following:

A. Alum.
B. Pickle Liquor.
C. Ferric Chloride.
D. Polymer.

23. Discuss advantages to adding iron salts before or during aeration.

24. Discuss the use of specific gravity in the adjustment of chemical feed rates.

25. Describe the affect of recycle streams on chemical feed rates.

26. Explain how temperature affects the following phosphorus removal chemicals.

A. Ferrous Sulfate.
B. Alum.
C. Polymers.
D. Ferrous Chloride.
E. Ferric Chloride.

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MODULE C: MONITORING AND TROUBLESHOOTING

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CONCEPT: MONITORING

27. Identify optional pH ranges for biological and chemical phosphorus removal.

28. Describe the laboratory quality assurance procedures for good phosphorus laboratory data.

29. Discuss the design and procedures for conducting a jar test and how the results can be related to the effectiveness of a phosphorus removal system.

30. Define "percent acid."

CONCEPT: TROUBLESHOOTING

31. Explain the circumstances where it may be better to dilute pickle liquor with water than to feed it undiluted.

32. Discuss potential problems with heavy metal in pickle liquor.

33. List possible reasons for higher than anticipated costs for phosphorus removal.

34. Describe the corrective actions for the following causes of poor phosphorus removal.

A. Loss of solids in the effluent.
B. Chemical feed problems (pumping or crystallization of chemicals).
C. Increase in phosphorus concentration.
D. Severe Biological upset.
E. High phosphorus in the in-plant side streams.
F. High sulfide wastes.
G. Less active metal in a new load of chemical.
H. pH out of optimum range.
I. Inadequate mixing of chemicals.
J. Significant decrease in sludge age.

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MODULE D: SAFETY AND CALCULATIONS

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CONCEPT: SAFETY

35. Define the hazards associated with common phosphorus removal chemicals.

36. Discuss safety procedures associated with Iron-Acid mixtures used for phosphorus removal.

37. Discuss special safety procedures relevant to powdered phosphorus removal chemicals.

CONCEPT: CALCULATION

38. Given data, calculate the amount of solution required to remove a given amount of phosphorus.

39. Given data, calculate the water pump setting (gallons/minute) required to achieve a desired dilution.

40. Given data, calculate the mole ratio of metal precipant (Fe or Al) to P_{inf}).

41. Given data, calculate the cost per pound of phosphorus removed ($/pound of P_{inf}).

42. Given data, calculate a phosphorus surcharge.

43. Given data, calculate the amount of feed chemical required to remove a specific quantity of phosphorus.

44. Given data, calculate the percent acid content.

RESOURCES

1. **ADVANCED WASTE TREATMENT**. 1st Edition (1987), Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

2. **APPLIED MATH FOR WASTEWATER TREATMENT PLANT OPERATORS**. (1991), Joanne Kirkpatrick Price. Technomic Publishing Company, Inc. 851 New Holland Avenue, Box 3535 Lancaster, PA 17604, U.S.A. Phone 800-223-9936 or 717-291-5609.

3. **BIOLOGICAL WASTEWATER TREATMENT**. (1980), Grady & Lim. M. Dekker Publishing Company. New York.

4. **CONTROLLING WASTEWATER TREATMENT PROCESSES**. (1984). Cortinovis, Dan. Ridgeline Press, 1136 Orchard Road, Lafayette, CA 94549.

5. **FINANCING AND CHARGES FOR WASTEWATER SYSTEMS**. (1984). Water Environment Federation (Old WPCF), 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206.

6. **OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS**. Manual of Practice No.11(MOP 11), 2nd Addition (1990), Volumes I,II,andIII. Water Environment Federation (Old WPCF), 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206.

7. **OPERATION OF WASTEWATER TREATMENT PLANTS**. Manual of Practice No.11 (MOP 11)(1976). Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206. (Probably Out-Of-Print, See Reference Number 4)

8. **PHOSPHORUS REMOVAL**. Design Manual EPA/625/1-87/001 (1987). U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, P.O. Box 12505, Cincinnati, OH 45212.

9. **PHOSPHORUS REMOVAL UPDATE - NEW INFORMATION GATHERED DURING THE EXAM REVISION PROCESS**. (1989). Gottlieb,Judith; McCarty,Glen; and, Steinbach, Tom. Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.(Copies available from your district coordinator).

10. **RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)**. (Revised 1992), Code of Federal Regulations, Parts 261-270. US-EPA, Region V, Waste Management Division, P.O. Box A3587, Chicago 60690.

11. **SIMPLIFIED WASTEWATER TREATMENT PLANT OPERATIONS**. (1995), Edward J. Haller. Technomic Publishing Company, Inc. 851 New Holland Avenue, Box 3535 Lancaster, PA 17604, U.S.A. Phone 800-223-9936 or 717-291-5609.

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